LONG ISLAND WATER RESOURCES
BULLETIN 10

DISTRIBUTION OF GROUND-WATER WITHDRAWALS ON LONG ISLAND, NEW YORK, IN 1973 BY AREA, AQUIFER, AND USE

Prepared by the

U.S. GEOLOGICAL SURVEY

in cooperation with the

NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION
NASSAU COUNTY DEPARTMENT OF PUBLIC WORKS
SUFFOLK COUNTY DEPARTMENT OF HEALTH SERVICES
SUFFOLK COUNTY WATER AUTHORITY

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SUFFOLK COUNTY WATER AUTHORITY

1979

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(in pocket)

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Multiply Inch-pound units	by	To obtain SI units
mile (mi)	1.609	kilometers (km)
square mile (mi^2)	2.59	square kilometers (km^2)
million gallons per day (Mgal/d)	0.04301	cubic meters per second (m^3/s)

DISTRIBUTION OF GROUND-WATER WITHDRAWALS ON LONG ISLAND, NEW YORK, IN 1973 BY AREA, AQUIFER, AND USE

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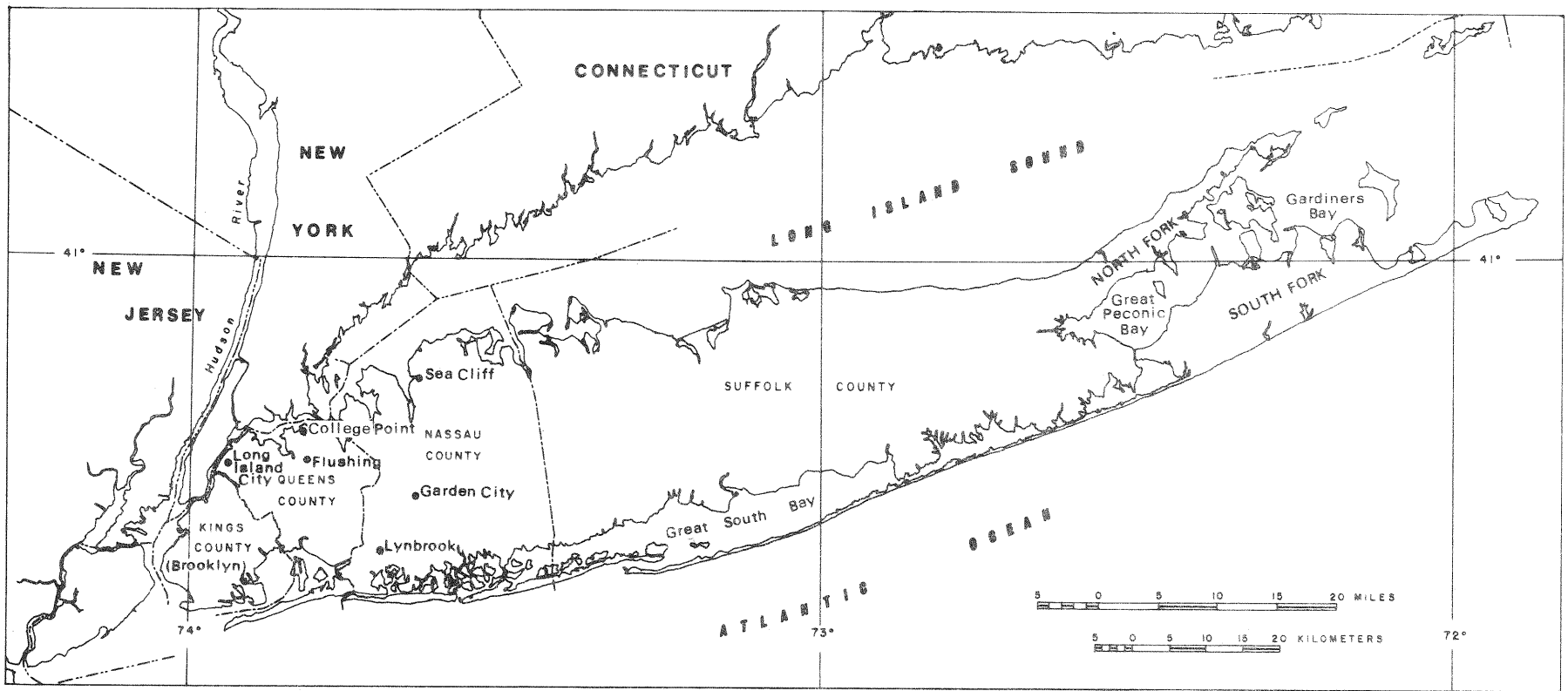
ABSTRACT

Use of ground water on Long Island has increased dramatically with continued eastward urbanization and population growth. Annual total ground-water withdrawals for all uses have increased steadily since the 1880's to 496 million gallons per day (Mgal/d) in 1973. Public-supply withdrawals in 1973 accounted for 75 percent of this total; commercial-industrial withdrawals accounted for 23 percent, and agricultural withdrawals 2 percent.

Total withdrawals on Long Island more than doubled between 1940 and 1973, from about 220 to 496 Mgal/d. From 1952 to 1973, public-supply withdrawals increased by more than 50 percent, from 144 to 374 Mgal/d; most of this increase was from the Magothy aquifer. Pumping density decreases eastward, in direct proportion to population density. The greatest pumping density is in urban Queens County; the smallest is in eastern Suffolk County. The greatest rate of increase in ground-water withdrawals today on Long Island is in western and central Suffolk County, where development and urbanization are also taking place at the fastest rate.

Withdrawals during 1973 are reported by use, county, and source aquifer. Maps showing areal distribution of public-supply withdrawals by source aquifer in 1973 and 1952 are included for comparison.



Base from U.S. Geological Survey
State base map, 1:500,000, 1974

Figure 1.--Location and major geographic features of Long Island, New York.

INTRODUCTION

The ground-water reservoir of Long Island, New York, is the sole source of freshwater supply for more than 3 million people on the island. Because the island's demand for freshwater is expected to increase, the use and proper management of ground water have become topics of growing concern and intensive study. Near the beginning of the 20th century, water-use managers realized that in areas of heavy ground-water use, monitoring of withdrawals would be essential for the protection of water resources. Since about 1900, pumpage data on Long Island have been collected, compiled, and published to provide a basis for water-use management. This report documents the 1973 withdrawals for major uses--public supply, industrial-commercial, and agricultural--and describes trends in ground-water withdrawal across Long Island from 1952 to 1973 by use, geographic area, and source aquifer.

The New York State Department of Environmental Conservation provided access to historic and current pumpage data. Gratitude is extended to staff members of that Department, particularly Robert J. O'Reilly and Anthony A. Candela, for their assistance in compiling 1973 pumpage data.

Description of Area

Long Island contains four counties--Kings, Queens, Nassau, and Suffolk (fig. 1). The two westernmost counties (Kings and Queens) are boroughs of New York City. The total length of Long Island is about 120 miles; its maximum width is about 23 miles, and its total area is about 1,400 mi^2. The 1970 population figure (rounded) of each county is as follows (New York State Division of the Budget, 1973):

Kings.....2,602,000
Queens....1,987,000
Nassau....1,429,000
Suffolk...1,127,000
TOTAL.....7,145,000

The ground-water reservoir of Long Island consists of saturated unconsolidated deposits that overlie southward-dipping, crystalline bedrock. The deposits consist of gravel, sand, silt, and clay, and may be classified into major hydrogeologic units on the basis of their regional extent and water-bearing characteristics. Units of primary concern to water managers are aquifers that yield substantial amounts of water. The major hydrogeologic units in the Long Island ground-water reservoir and their general characteristics are summarized in table 1; the vertical relationship of these units is depicted in figure 2.

Table 1.--Hydrogeologic units on Long Island, New York [1/]

Hydro-geologic unit	Geologic name and age		Approximate maximum thickness (feet)	Lithology and water-bearing character
Upper glacial aquifer	Upper Pleistocene deposits	QUATERNARY	750	Mainly sand and gravel; moderate to high permeability; also includes clayey deposits of till of low permeability.
Gardiners Clay	Gardiners Clay	QUATERNARY	150	Clay, silty clay, and a little fine sand; low to very low permeability; confines water in underlying units.
Jameco aquifer	Jameco Gravel	QUATERNARY	250	Mainly sand and gravel; high permeability; unit occurs only in Queens and southwestern Nassau Counties.
Monmouth greensand	Monmouth Group	CRETACEOUS	200	Clay, silt, and sand containing much glauconite and lignite; low to very low permeability; unit occurs only along south shore in Suffolk County, where it confines water in the underlying Magothy aquifer.
Magothy aquifer	Matawan Group Magothy Formation undifferentiated	CRETACEOUS	1000	Coarse to fine sand; moderate permeability; locally contains gravel of high permeability, and abundant silt and clay of low to very low permeability.
Raritan Clay	Clay member of the Raritan Formation	CRETACEOUS	300	Clay of very low permeability; some silt and fine sand and fine sand of low permeability; confines water in the underlying Lloyd aquifer.
Lloyd aquifer	Lloyd Sand Member of the Raritan Formation	CRETACEOUS	550	Sand and gravel of moderate permeability; some clayey material of low permeability.
Bedrock	Precambrian(?) bedrock		Basement complex	Crystalline rocks; forms basement of the ground-water reservoir on Long Island.

1/ See also Cohen and others (1968), Franke and McClymonds (1972), Jensen and Soren (1974), Soren (1971).

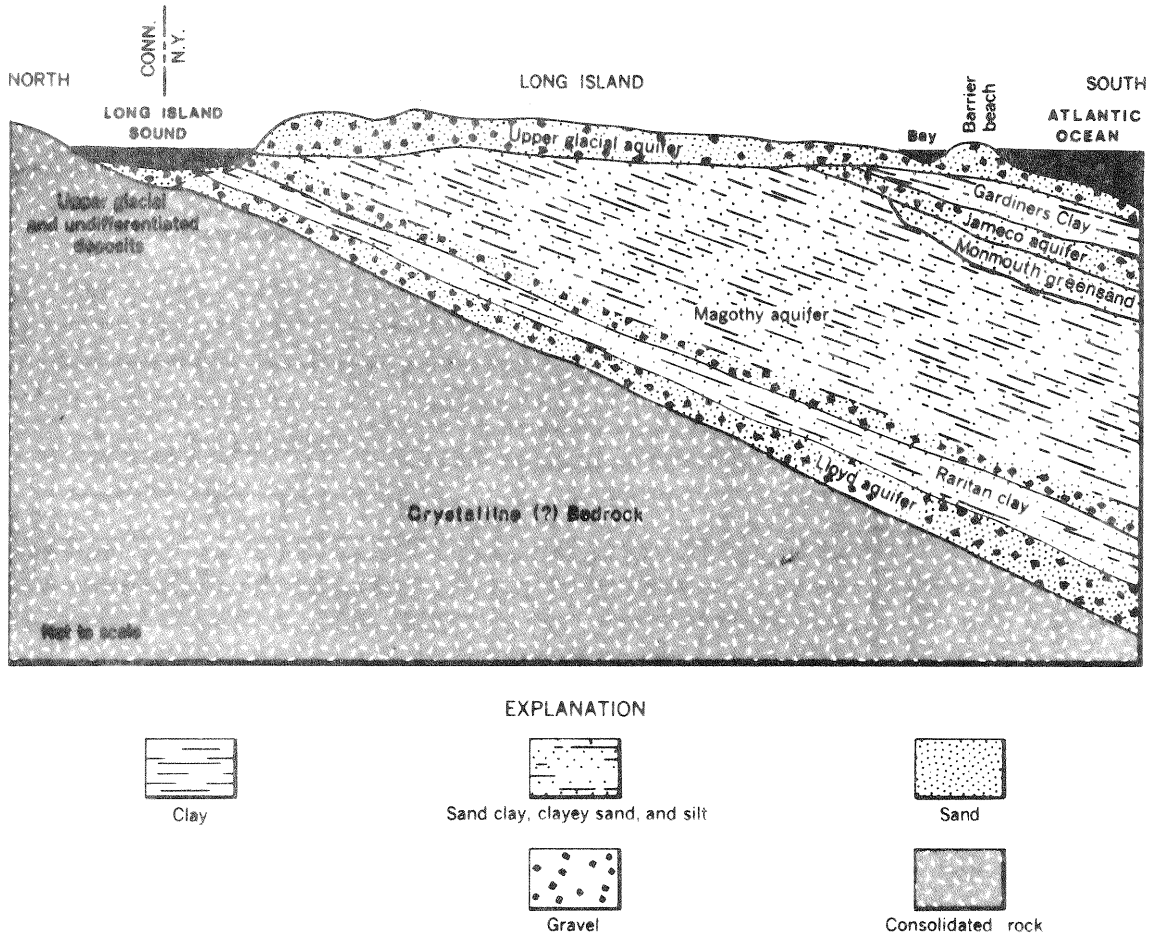


Figure 2.--Generalized cross section showing major hydrogeologic units on Long Island.

MAJOR CATEGORIES OF GROUND-WATER USE

Ground water has been withdrawn in substantial quantities on Long Island since the late 19th century; the amount has been increasing dramatically since the end of World War II and reached an average total of 496 Mgal/d in 1973. Withdrawals are classified in this report into three categories according to use: (1) public supply, which includes pumpage from individually owned wells and from franchised water suppliers; (2) industrial-commercial use, which includes institutional pumpage as well as private commercial and industrial uses; and (3) agricultural pumpage for irrigation. The largest of these categories is public supply, which, according to New York State Department of Environmental Conservation records, constitutes about two-thirds of the island's total annual withdrawals. Industrial-commercial use accounts for one-quarter to one-third of the annual pumpage annually, and agricultural pumpage constitutes less than one-tenth of the annual total. Figure 3 depicts the total withdrawals as average daily pumpage, in millions of gallons, during 1948-73 and gives the corresponding amount for each use.

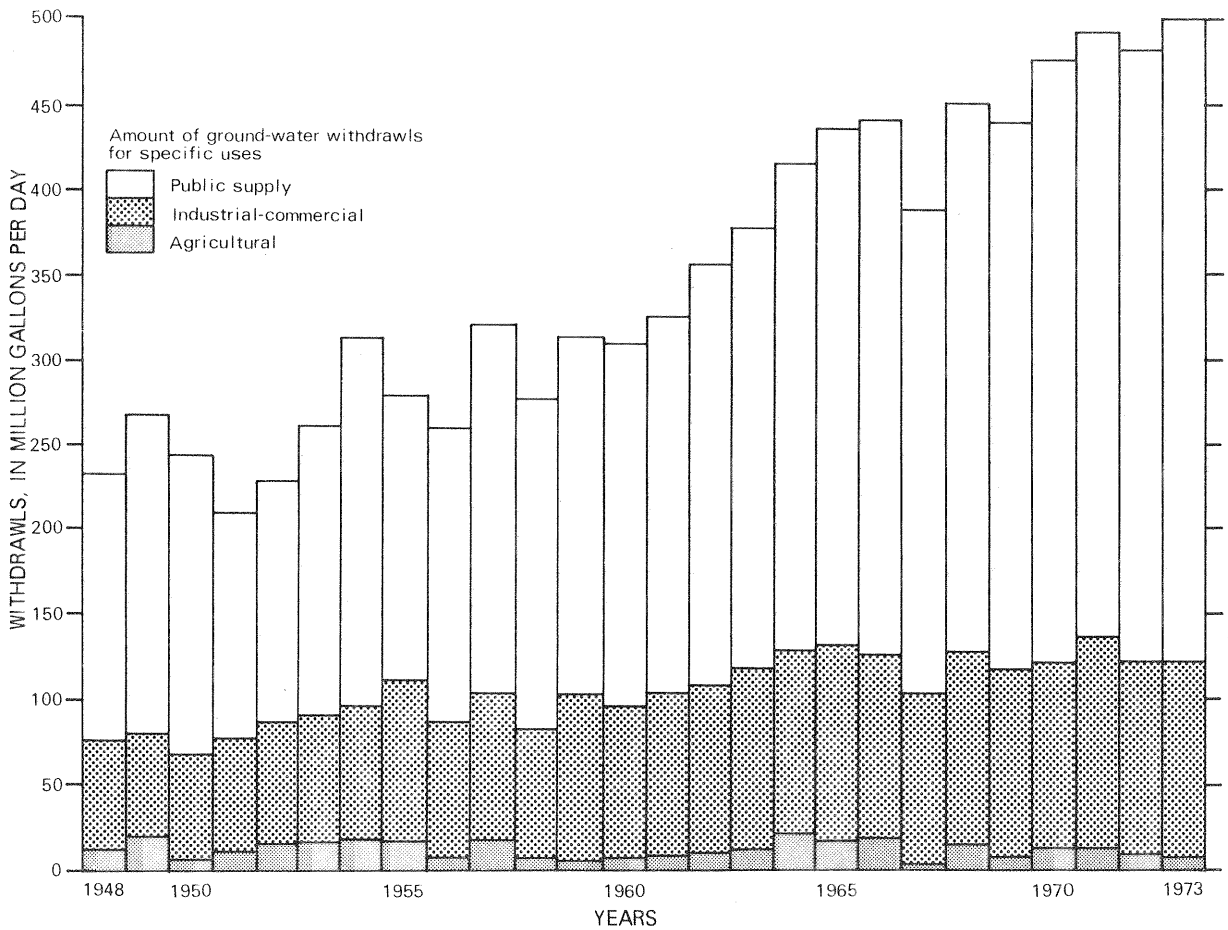


Figure 3.--Total ground-water withdrawals on Long Island, by use, 1948-73.

HISTORY OF LONG ISLAND GROUND-WATER WITHDRAWALS

Ground-water development on Long Island began in the 1600's, when the first European settlers used shallow dug wells to supplement springs, streams, and ponds as a source of freshwater (Soren, 1971, p. 23). The first public-supply system, completed in Brooklyn in 1862, used surface water from several streams between Brooklyn and Lynbrook in southwest Nassau County (fig. 1). In the early 1870's, other water-supply systems that used only surface water were established in Sea Cliff and College Point, in northwestern Nassau County, and Flushing, in northern Queens County (fig. 1). Also during the 1870's, the first public-supply well was completed in Long Island City, northwestern Queens County. Shortly thereafter, another public-supply system that depended on ground water was built in Garden City, in central Nassau County (Veatch and others, 1906, p. 74).

Beginning in 1880, the surface-water supply for Brooklyn was supplemented by wells in Queens and Nassau Counties, and soon the development of ground water for public supply increased sharply as new local systems dependent on wells were constructed. As determined from reports by the Merchants' Association of New York (1900, p. 157), Burr and others, (1904, p. 58-62), Veatch and others (1906, p. 75), and the City of New York Board of Water Supply (1912, table 6), total ground-water withdrawals for all uses on Long Island before 1900 were probably less than 60 Mgal/d. Veatch and others (1906, p. 75) estimated that the total ground-water withdrawals on Long Island in 1902 averaged 55 Mgal/d, more than half of which was used in Brooklyn.

Annual total ground-water withdrawals for public supply and institutional uses on Long Island during 1904-34 ranged from 47 to 151 Mgal/d and averaged 113 Mgal/d, according to reports by Thompson and Leggette (1936, p. 7), Suter (1937, p. 35-36), Lusczynski (1950, fig. 1), Roberts (1951, table 3), and Lusczynski and Spiegel (1954, table 1). Between 1940 and 1973, the annual total withdrawal for all uses more than doubled from 220 Mgal/d (Cohen and others, 1968, p. 70) to 496 Mgal/d.

Saltwater intrusion, mainly into the upper glacial aquifer as a result of heavy pumping in western Long Island during the first half of the 20th century, made it necessary to halt public-supply pumpage in Kings County in 1947 (Lusczynski, 1952, p. 1). Subsequently, saltwater intrusion in western Long Island caused the cession of some withdrawal for public supply in Queens County in 1974 (Soren, 1976, p. 3).

In the early 1950's, public-supply withdrawals increased sharply in Nassau County in direct proportion to population growth. Both population and ground-water withdrawals increased sharply in Suffolk County in the early 1960's. Figure 4 illustrates the annual total public-supply withdrawals on Long Island, from 1948 to 1973, expressed as average daily withdrawals by county. In Queens County, the predominant use of upstate surface water and a relatively stable population resulted in a very small increase of ground-water pumpage compared with the sharp increases in Nassau and Suffolk Counties.

During 1948-73, industrial-commercial pumpage in Nassau and Suffolk Counties rose sharply along with that for public supply. However, average industrial-commercial withdrawals in Kings and Queens Counties during that period remained fairly constant (fig. 5). As housing development in Nassau County increased through the 1950's, agricultural pumpage declined to an average of less than 0.5 Mgal/d in 1958 and has remained at that level to the present, as indicated in figure 6. Kings and Queens Counties have no known agricultural withdrawals, and agricultural pumpage in Suffolk County depends largely on the amount of precipitation during the growing season. No consistent long-term trend was evident in pumpage for agricultural use in Suffolk County during 1948-73.

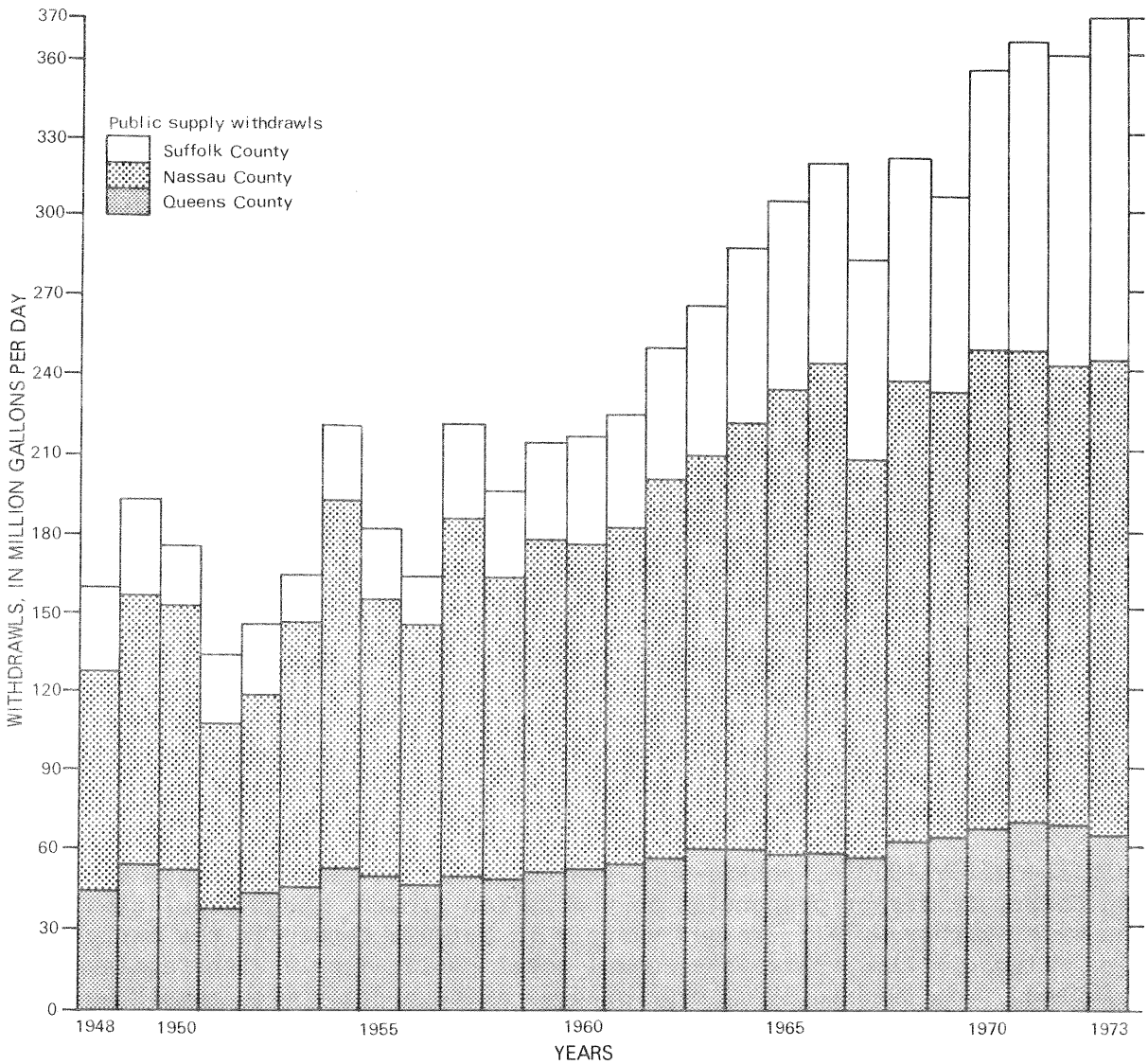


Figure 4.--Public-supply withdrawals by county, 1948-73.

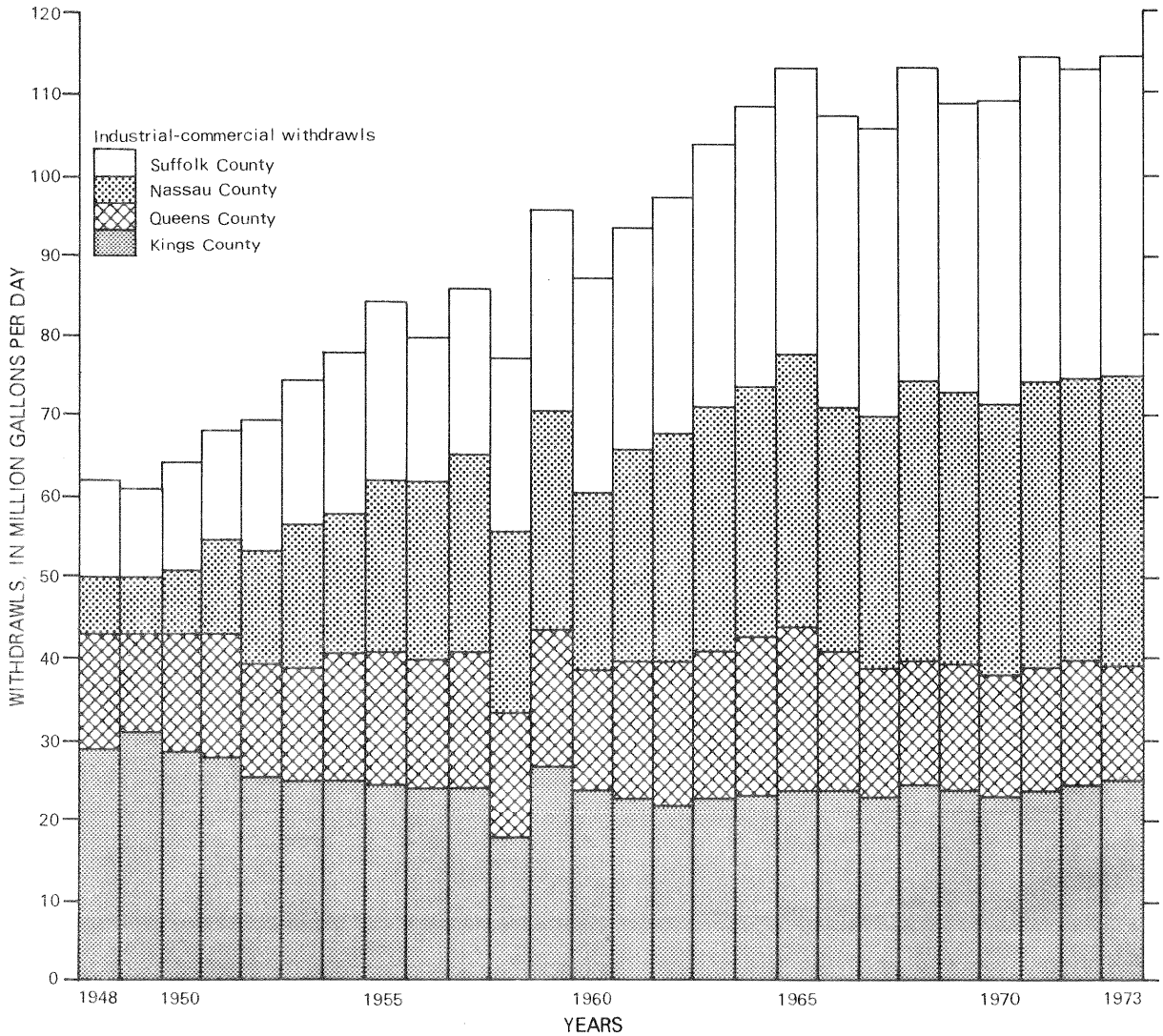


Figure 5.--Industrial-commercial withdrawals by county, 1948-73.

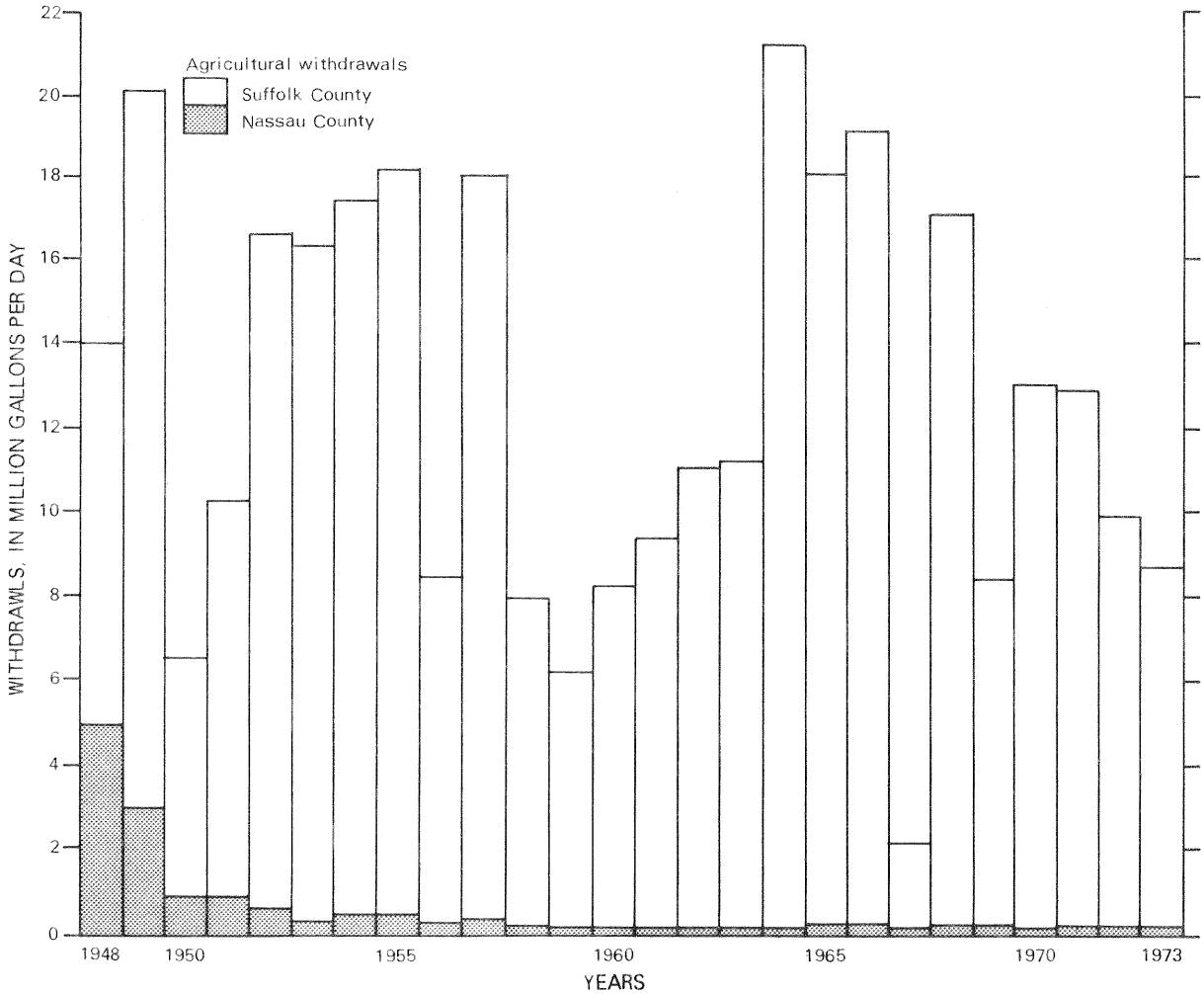


Figure 6.--Agricultural withdrawals by county, 1948-73.

GROUND-WATER WITHDRAWALS IN 1973

Figures on ground-water withdrawals in 1973 are based on reports from water users who regularly submit pumpage data to the New York State Department of Environmental Conservation. Public supply is the most closely monitored pumpage and is, therefore, the most accurately determined; public supply also constitutes the greatest percentage of total withdrawals throughout Long Island and represents 75 percent of the 1973 total.

Total ground-water withdrawal on Long Island in 1973 was 496 Mgal/d. Of this amount, the average total for each major use was as follows:

public supply.....373.7 Mgal/d
industrial-commercial.....113.8 Mgal/d
agricultural.....8.7 Mgal/d

The approximate totals in each county were as follows:

Kings.....25 Mgal/d
Queens.....79 Mgal/d
Nassau.....214 Mgal/d
Suffolk.....178 Mgal/d

Table 2 summarizes the 1973 pumpage in each county for each of the three types of use.

Table 2.--Ground-water withdrawals by county and use, 1973

[*in millions of gallons per day*]

County	Public supply	Industrial-commercial	Agricultural	Total amount withdrawn
Kings	0	24.8	0	24.8
Queens	65.2	14.2	0	79.4
Nassau	178.5	35.6	.08	214.2
Suffolk	130.0	39.2	8.6	177.8
TOTAL	373.7	113.8	8.7	496.2

During this study, the aquifer tapped by each public-supply well was identified, and withdrawals from each aquifer were tabulated. The areal distribution of public-supply withdrawals, according to aquifer and water-supply areas, is depicted in plate 1-A. Each water-supply area in plate 1-A represents either one water district or two or more water districts combined. Withdrawals are compiled by aquifer for each water-supply area.

Public-supply withdrawals within water-supply areas are represented by circles proportional in size to the total pumpage in 1973. The sectors of each circle indicate the proportion of pumpage from each aquifer in that area. In 1973, the largest withdrawals per unit area, or greatest pumping density (largest public-supply withdrawals per unit area), was in southern Queens and southwestern Nassau Counties. Pumping density throughout the rest of Nassau and western Suffolk Counties was fairly uniform but less than in southern Queens and southwestern Nassau Counties. In central Suffolk County, pumping density was considerably lower than in western Suffolk and was least dense in eastern Suffolk. The pumping density throughout the island correlates closely with population density.

The percentage of water pumped from each aquifer on Long Island differs from area to area. In Nassau County in 1973, the Magothy aquifer was the predominant source of public supply, whereas in Suffolk County, the Upper glacial aquifer was generally the major source for public supply except in the more densely populated, western (especially southwestern) parts, where withdrawals from the Magothy were predominant. Withdrawals from the Lloyd aquifer in Suffolk County in 1973 were insignificant, and the Jameco aquifer does not extend into Suffolk County (Jensen and Soren, 1974, sheet 1). In central Queens County in 1973, extensive pumpage from the Magothy and upper glacial aquifers was supplemented with minor withdrawals from the Lloyd and Jameco aquifers. No public-supply withdrawals have been made in Kings County since 1947.

A comparison of 1973 pumpage (plate 1-A) with that of 1952 (plate 1-B) reveals the effect of population increase and urbanization during that period on public-supply withdrawals. Suffolk County is omitted from the 1952 map (plate 1-B) because public-supply withdrawals there were very small and scattered. Total withdrawal in Suffolk County in 1952 was 25 Mgal/d--less than one-fifth the county's 1973 total of 130 Mgal/d. During the early 1950's, a large part of the Suffolk County population obtained water from private domestic wells; these withdrawals (and public-supply pumpage by water companies) were mostly from the upper glacial aquifer.

The pumpage distribution in 1952 reflects the beginning of eastward development and urbanization through Queens County into western and central Nassau County (plate 1-B). The largest public-supply withdrawals in that year, indicated by the largest circle on the map, were in southern Queens County. Public-supply withdrawals in western and central Nassau County were considerably smaller than in Queens County but were considerably greater than those in eastern Nassau County. The pattern of withdrawals in plate 1-B shows also that the south shore of Nassau County was generally more developed than the north shore. In the eastern part of the island, withdrawals for public supply remained low; withdrawals in Suffolk County were too small and scattered for significant representation on the map.

The most obvious difference between the pumpage patterns on Long Island in 1952 and 1973 is the large increase in total withdrawals. In 1952, average public-supply withdrawals totaled 144 Mgal/d and had increased by 250 percent by 1973 to an average 374 Mgal/d. Most of the increase for public supply in Nassau County from 1952 to 1973 was from the Magothy aquifer; 138 Mgal/d, or 82 percent of the 168-Mgal/d increase in public-supply pumpage during this period, was from the Magothy aquifer. In Queens County during the same period,

withdrawals from the Magothy aquifer increased by 26 Mgal/d or 68 percent, whereas the total public-supply pumping in Queens County increased by only 23 Mgal/d, or 21 precent. The percentage increase in pumping from the Magothy aquifer throughout the island was greater than the total percentage increase in pumpage during this period because pumping from the upper glacial and Jameco aquifers had been decreasing as a result of water-quality problems. Withdrawals from the Lloyd aquifer in Queens County from 1952 to 1973 remained virtually unchanged because additional withdrawals were prohibited by New York State (Soren, 1971, p. 26) in order to reserve use of this aquifer for coastal areas.

The most pronounced changes in the Long Island pumping pattern occurred after World War II, when areal populations increased mostly eastward. As a result, the distribution of public-supply withdrawals on the map for 1973 (plate 1-A) is more uniform than that on the map for 1952 (plate 1-B). This relatively even distribution reflects the fact that urbanization had stabilized to a fair degree by 1973 throughout Queens and Nassau Counties.

Although the amount and pattern of public-supply withdrawals had nearly stabilized by 1973 in western Long Island, urban development and public-supply withdrawals in eastern Long Island were still rapidly increasing. By 1973, the pumpage pattern in Suffolk County generally resembled the 1952 pattern in Nassau County, and the largest public-supply withdrawals were in the western part of the county. Although no maps are given for comparison of 1952 and 1973 pumpage patterns in Suffolk County, the pattern of withdrawals from the Magothy aquifer in 1973 (plate 1-B) reflects continued eastward urbanization. From west to east, the percentage of public-supply withdrawals from the Magothy aquifer in Suffolk County in 1973 was as follows: west, 65 percent; central, 40 percent; east, 25 percent. This pattern contrasts sharply with the more uniform distribution and the larger withdrawals from the Magothy aquifer throughout Nassau County in 1973.

SUMMARY

Ground-water use on Long Island has changed dramatically as a result of eastward development and population growth. Annual total of ground-water withdrawal for all uses has steadily increased on the island since around 1880 and more than doubled between 1940 and 1973, when it increased from 220 to 496 Mgal/d.

Public-supply withdrawals increased most rapidly during the periods of fastest population growth--the late 1940's and early 1950's in Nassau County, and the early 1960's in Suffolk County. Industrial and commercial withdrawals in Nassau and Suffolk Counties increased concurrently with public-supply withdrawals. From the mid- to late 1950's, agricultural withdrawals decreased in Nassau County but have remained relatively constant to the present (1977) in Suffolk County, especially in the eastern part, where urbanization has been least.

In 1973, the greatest pumping density was in southern Queens and southwestern Nassau Counties. Pumping density in the rest of Nassau and western Suffolk Counties was fairly uniform, but withdrawals were smaller than in southern Queens and southwestern Nassau Counties. In Suffolk County, pumping density thinned eastward and was least dense in the eastern part of the county. Total 1973 public-supply withdrawals, and also the percentage of water pumped from each aquifer, varied from place to place across the island. In general, both the total withdrawals and the percentage of withdrawals from the Magothy aquifer were largest where urbanization was most extensive.

The change most obvious in comparing the 1952 and 1973 public-supply withdrawals is the large increase in total amount of water pumped. Public-supply withdrawals increased about 2.5 times from an average total of 144 Mgal/d in 1952 to 374 Mgal/d in 1973. Most of this increase consists of new pumpage from the Magothy aquifer. In Nassau County, 138 Mgal/d or 82 percent of the total 168 Mgal/d increase in public-supply pumpage from 1952 to 1973 was from the Magothy aquifer. Moreover, in Queens County, the 26 Mgal/d increase in public-supply withdrawals from the Magothy aquifer, is greater than the total increase of 23 Mgal/d owing to decreased withdrawals from other aquifers.

Pumpage records for 1952 reflect the beginning of rapid eastward development and urbanization through Queens County into western and central Nassau County. Largest withdrawals were in southern Queens County, where population was greatest. Withdrawals in western and central Nassau County were considerably less than those in Queens County but were considerably larger than those in eastern Nassau County. Also, the larger pumping on the south shore than the north shore of Nassau County in both 1952 and 1973 generally reflects the greater extent of development on the south shore. Pumping density has always been lowest in the eastern part of Long Island; withdrawals in eastern Suffolk County have been too small to show any change in development pattern.

The most obvious difference between 1952 and 1973 public-supply withdrawals islandwide, other than the total amount of water pumped, is the largest increase in the percentage of water pumped from the Magothy aquifer. Public-supply withdrawals increased by about 250 percent, from an average total of 144 Mgal/d in 1952 to 374 Mgal/d in 1973. Most of this increase consisted of new pumpage from the Magothy aquifer. In Nassau County, 138 Mgal/d, or 82 percent of the total 168-Mgal/d increase in public-supply pumpage from 1952 to 1973, was from the Magothy aquifer.

In Nassau County, pumpage from the Magothy aquifer increased substantially from 1952-73, and the distribution of withdrawals from the Magothy aquifer for public supply throughout the county had become more uniform by the end of that period. Although the amount and pattern of withdrawals had nearly stabilized by 1973 in Nassau County, urbanization and pumpage were still increasing significantly in eastern Long Island. In 1973, the continued eastward development and urbanization in Suffolk County was reflected in a pumpage pattern generally analogous to the 1952 pattern in Nassau County. In Suffolk County, public-supply withdrawals have remained greatest in the western part of the county. The pattern of withdrawals from the Magothy aquifer in Suffolk County reflects eastward urbanization.

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